grades of structural evolution, will be found acceptable by many systematists.

It would be impossible to follow Mr. Smith Woodward in these columns into the details of his work, but there are one or two points to which I may direct attention. The wide separation of Coccosteus from Ptericthys is a bold stroke, and one for which much solid argument is adduced, Coccosteus and its allies appearing to fit in with the Dipnoi, whilst Ptericthys finds allies in Cephalaspis, Pteraspis, and Didymaspis. Dr. Traquair's valuable researches are largely used and acknowledged by Mr. Smith Woodward, and he does not hesitate to accept the former author's association of the large family of the Palæoniscidæ with the Sturgeons, which, as the Chondrostei, form the first sub-order of the Actinopterygian Teleostomi, the point up to which this valuable work has now been brought.

Of my old friends Cephalaspis, Pteraspis, and their allies, Mr. Smith Woodward has a great deal which is extremely interesting to say. It appears that the conclusion (which I resisted in my monograph published by the Palæontographical Society, and elsewhere) is now pretty well demonstrated by new and well-preserved specimens (described by von Alth), viz. that the plates to which I gave the name Scaphaspis are really the ventral plates of the associated species of Pteraspis. Mr. Smith Woodward is able by means of this view to give a more correct interpretation of my specimen of the scales of Pteraspis than I was able to do. It is now in the collection of which this catalogue treats, and remains the only specimen of the body-covering of these fish. The possibility of this relationship of Scaphaspis and Pteraspis was often discussed and considered at the time when I wrote on these fossils, and I was careful to point out the constant association of *Sc. Lloydii* with *Pteraspis rostratus*, of *Sc. rectus* with *Pt. Crouchii*, and of *Sc. truncatus* with *Cyathaspis Banksii*. But no British specimens were forthcoming (although we had hundreds to examine) showing any connection of the two shields as parts of one animal. The remarkable genus to which I gave the name Holaspis (which, being preoccupied by the late Dr. Gray, has had to give place to Mr. Claypole's Palæaspis of ten years later date) seemed to confirm the view that Scaphaspis was a simplified shield of the same character as Pteraspis, Holaspis or Palæaspis being intermediate in complexity. But the specimen described and figured by von Alth leaves no doubt in my mind as to the interpretation of Scaphaspis adopted by him. The absence of the canal system, so well developed in Pteraspis and Palæaspis, is an argument against Scaphaspis being, like those forms, a dorsal cephalic plate.

There are matters with regard to Didymaspis and Eukeraspis (genera of mine which I am glad to see surviving Mr. Smith Woodward's crucible) and Cephalaspis on which new light is thrown in the "Catalogue," which, however, I must not take space to detail. A very interesting thing connected with our Herefordshire cornstones is the discovery, by Dr. Traquair, of a Coccostean, *Phlyctænaspis anglica*, in specimens which I had supposed might be portions of the large *Cephalaspis salweyi*. Quite a series of these specimens are recorded in the "Catalogue" as being in the national collection, whilst in Oxford we have some excellent specimens amongst the other treasures of the Grindrod Collection, which has been purchased for the University Museum.

Sixteen beautifully lithographed plates and numerous woodcuts illustrate this second volume of the "Catalogue of Fossil Fishes."

One last word as to a matter of word-making. I congratulate Mr. Smith Woodward on having the good sense to write "Pteraspidæ" instead of "Pteraspididæ," and "Asterolepidæ" instead of "Asterolepididæ." It would *not* have been more correct to write the longer form, and would have been pedantic.

E. RAY LANKESTER.

THE HONEY BEE.

The Honey Bee: its Natural History, Anatomy, and Physiology. By T. W. Cowan, F.L.S., F.G.S., F.R.M.S., F.S.Sc., &c. Illustrated with Seventy-two Figures of 136 Illustrations. (London: Houlston and Sons, 1890.)

THE interior economy of the hive is known intimately to every bee-keeper; with the anatomy of its makers, rulers, citizens, not one in a hundred is familiar. The mass of facts accumulated during two centuries of discovery lies for the most part embalmed in the Proceedings of Societies, locked up in costly monographs, untranslated from foreign languages: for the first time it is here presented to English readers, in a form at once exhaustive and concise, by the most accomplished of modern apiarians. Careful compilation from former writers, enriched with much matter that is wholly new, conscientious exclusion of theories unverified by experiment, accuracy of illustration secured by direct drawing from photo-micrographs or microscopical preparations, justify, we think, with the deductions inseparable from a first attempt, Mr. Cowan's claim to have produced "the most perfect work of its kind."

From its pages bee-keepers will learn the extent to which the romantic stories current as to their favourites are borne out by scientific research or must be abandoned. They will find the most startling of all, parthenogenesis in the young hive-mother, to be an established fact; the unwedded queen lays eggs profusely, but all of them give birth to drones. No less certain is the derivation of queens and workers respectively from the different kinds of food administered to them in their larval state. The future queen is fed on "chyle-food," elaborated in the chyle-stomach of the nurses, until it assumes the chrysalis change, from which it emerges a perfect female. The future worker is weaned upon the fourth day, and fed henceforth on honey and digested pollen, with the result that its ovaries are rudimentary and sterile, while its further genital structure renders it incapable of mating. The fecundation of the queen takes place within a few days of her quitting the cell, and lasts for life; the millions of spermatozoa injected being imprisoned in a special receptacle, retaining their vitality throughout her lifetime, and escaping one by one to fertilize each egg as it is laid. Similar storage power is present in the digestive system. The food swallowed by the mouth passes, not into the stomach, but into a temporary reservoir, called the honey-sac, from whence it can at will be regurgitated into the cells, or passed into the stomach through a

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valvular orifice, called the stomach-mouth, a construction which "permits the bee to eat when, where, and how she pleases, without having to trouble her mouth in any way." And this strange power extends even to the respiratory process, one or two rapid breaths so charging the tracheæ, that for the next three minutes no further inhalation is required. One singularly interesting belief is shattered by Mr. Cowan—that the accuracy of comb structure is due to "mathematical instinct." The story of Maraldi's measurements and of Kœnig's miscalculations, of the error in a book of logarithms discovered by the exquisite precision of bee mensuration in constructing the lozenge-shaped plates which form the basis of the cells, has been popularized by many writers. Mr. Cowan's observations show that in no carefully measured piece of comb are all the diameters of the different cells or all the angles of the different plates identical, nor is their variation regular. Cells are sometimes square, sometimes acute-angled, sometimes roughly circular. The mechanical purpose of the bees is confined to the formation of a cylinder, but the mutual interference of the little architects, as in the case of impinging soap-bubbles or bottled peas, compels the hexagonal form.

Though shorn of its mathematical attributes, bee intelligence remains extraordinary. Their prescience, their power of exact mutual communication, the elaborate community of discipline and labour which characterize each colony, throw doubt on the familiar distinction which denies to lower animals the analytic faculty—accords perception to the bee or dog, conception to the human mind alone. Into this question Mr. Cowan does not enter; but we are not surprised to learn from him that the well-defined brain necessary to the possession of intelligence forms in the bee 1/174 part of the volume of the body, sinking in other insects as low as to the 1/4200 part.

The muscular power of the bee is as much in advance of man's as its intellectual power is inferior. A man's power of traction is far below the weight of his body; a bee can draw twenty times its own weight. Its flight exceeds twelve miles an hour, and it will go four miles in search of food. Its wings, braced together in flight by a row of hooklets, bear it forward or backward, with upward, downward, or suddenly arrested course, by a beautiful mechanical adaptation which the author admirably describes. Its voice-organs are three-fold, the vibrating wings, the vibrating rings of the abdomen, and a true vocal apparatus in the breathing aperture or spiracle: the first two produce the buzz; while the hum—surly, cheerful, or colloquially significant—is due to the vocal membrane. Some of its notes have been interpreted. "Huumm" is the cry of contentment; "Wuh-wuh-wuh" glorifies the incessant accouchements of the queen; "Shu-u-u" is the frolic note of young bees at play; "Ssss" means the muster of a swarm; "Brrr" the slaughter or expulsion of the drones; the "Tu-tu-tu" of newly-hatched young queens is answered by the "Qua-qua-qua" of the queens still imprisoned in their cells.

Enough has been said to indicate the interest and value of this compendium. For the description of the tongue, with its rod, spoon, tasting-hairs; of the pulvillus and its adhesive secretions; of the marvellous changes developed in the later metamorphosis of the imperfect insect; of the compound eyes with their mosaic vision, incapable, we suppose, through deficient muscular adjustment (though on this point Mr. Cowan is silent) of delineating to the bee mind a perceptual world resembling ours; of the sting and poison sac, of the wax pockets with their secreted scales, drawn out by the hind leg pincers, made malleable by mastication and saliva, kneaded into foundation walls and cells—the student must betake himself to the book. Full of matter as it is, it leaves much unsettled. The character of the sensory functions, the existence of gustatory and olfactory organs, the meaning of various unintelligible bodies in the antennæ, abdomen, labium, ligula, have not been determined—may perhaps never be understood; for "it is not impossible that insects may possess senses or sensations, of which we can no more form an idea than we should be able to conceive red or green if the human race were blind."

For the second edition of the book, which will doubtless be demanded, certain minor corrections or amendments may be suggested. If bees are *Hymenoptera*, the Greek word for a membrane (p. 2) may fairly be written hymen. In p. 12, ll. 15, 16; in p. 63, ll. 4-9; p. 102, l. 29, slight textual improvements are desirable. Near the bottom of p. 26 is an obvious printer's error. On p. 64, l. 11, the word "those" is not readily referable to the ganglia for which it presumably stands. The engraving on p. 25 is repeated on p. 96. The description of the brain, pp. 68, 69, is indistinct in places, and would gain if the illustrations, 31, 32, were lettered. So, again, the inversion of the male organ, pp. 129, 130, is not clear from Fig. 53. And is it impertinent to hope that the peroration may be re-written or struck out? By all means recognize formally, if it has not indeed been all along assumed, the benevolence and wisdom of a superintending Providence; but the pious platitudes of pp. 190-192 are an anti-climax to the clear reasoning and precise statement which are maintained throughout the scientific portion of the work, and leave on the critical palate an after-taste less sweet than honey to the mouth.

W. TUCKWELL.

ELECTRO-METALLURGY.

The Electro-plater's Hand-book. By G. E. Bonney. (London: Whittaker and Co., 1891.)

THIS book is designated as being a "practical manual for amateurs and young students in electro-metallurgy," and intended "to meet the wants of amateurs and young workmen desiring a practical manual in electro-plating at a low price."

It contains a large amount of sound information respecting the details of preparing metals for electro-plating; the processes of cleaning, polishing, scratch-brushing, &c.; a number of useful practical tables; numerous recipes for making plating solutions; descriptions of workshop appliances, tools, pieces of apparatus, &c., of immediate practical use to a working electro-plater; and it is essentially an ordinary workman's book.

In accordance with the statement made in the preface, that "it supposes the workman to have an elementary acquaintance with electrical science," the book contains

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